12-1-1975

An Investigation of Pure Tone Threshold During Menses and Post Menses Using Short Duration Signals

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AN INVESTIGATION OF PURE TONE THRESHOLD DURING MENSES AND POST MENSES USING SHORT DURATION SIGNALS

by
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Bachelor of Science,
University of North Dakota, 1974

A Thesis

Submitted to the Graduate Faculty

of the

University of North Dakota

in partial fulfillment

of the requirements

for the degree of

Master of Science

Grand Forks, North Dakota

December
1975

This Thesis submitted by Sandra Hedler Washer in partial fulfillment of the requirements for the Degree of Master Of Science from the University of North Dakota is hereby approved by the Faculty Advisory Committee under whom the work has been done.

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Department Speech Pathology & Audiology

Degree Master of Science

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ACKNOWLEDGEMENTS

I would like to gratefully acknowledge my Committee Chairman, Dr. George W. Schubert, for his interest, concern, and assistance given during the course of this study. His willingness to give of his time never seemed to cease. I would also like to thank Dr. Robert C. Meyer for his constant guidance and encouragement throughout the course of this study. I wish to extend my sincere appreciation to Dr. John D. Williams for his patience and cooperation.

Finally, I wish to thank my friends and family for their many kindnesses and continued support. I would like to thank Karen Cline for her cooperation in typing this thesis.

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ABSTRACT

The purpose of this study was to determine if threshold change occurred during menses and two post menses time periods. Sixteen female subjects, using the Bekesy tracing method, determined thresholds for 1 KHz and 4 KHz for signal durations of 2 msec, 20 msec, and 500 msec.

The results indicated that there was no significant difference ($p > .05$) for the thresholds of 1 KHz and 4 KHz at any duration over the three test times. However, there was a significant second degree trend present at 1 KHz for the 20 msec signal.

A comparison was made between the thresholds obtained by nine subjects who were using an oral contraceptive and seven subjects who were not. A significant difference ($p < .05$) between the groups was found at 4 KHz for the 2 msec signal duration in that the group using oral contraceptives obtained threshold at a lower intensity than did the group not using oral contraceptives.

Comparison of the thresholds and the slope of integration obtained in this study was in agreement with previous investigators.

CHAPTER I

INTRODUCTION

There have been few reported studies that have investigated the effect of the menstrual cycle on various auditory responses. Tobias (1973) reported that binaural beat perception was different for males and females. Binaural beats result from interaction in the nervous system rather than in the mechanical or acoustic system (Oster, 1973). A tone of one frequency is presented to one ear while a slightly differing frequency is presented to the other. The binaural beats are perceived as a warbling sound, whose frequency is equal to the difference between the two original tones.

Females do not perceive binaural beats at as high of frequencies as do males (Tobias, 1973). The highest frequency at which females could perceive beats was approximately 200 Hertz (Hz) below the maximum frequency for males. However, it was found that beat perception ability of females during menses coincided with that of males. There was no longer the lower frequency ceiling which occurred pre or post menses. It was also noted that there was a slight rise in the frequencies at which females perceived beats fifteen days after the onset of menses.

Tobias (1973) related this phenomena to minor physiological changes in that the VIII cranial nerve may conduct at a faster rate during menses to perceive higher frequencies. This assumption was based on information showing that impulses in the VIII cranial nerve are determined by the frequency of the pure tone. It was postulated that the neurons emit one nerve impulse for each cycle of a tone (Oster, 1973). Tobias (1973) suggested that variations in the emotional state also affected the ability of the female to perceive beats.

Temporal integration studies have also reported a difference in female subjects' responses dependent upon menses. Temporal integration refers to the process by which an observer's ability to detect acoustic stimulation decreases as the duration of the stimulus decreases from long to shorter durations (Richard and Dunn, 1974). The duration above which threshold does not commonly change is 200 milliseconds (msec). At durations shorter than this, threshold changes approximately 10 deciBels (dB) per decade decrease in time of duration (Sanders, 1971). Eisenberg (1956, p. 113) using a fixed intensity and measuring time-thresholds at which the stimulus was perceived, noted that a pregnant female had a markedly reduced time of integration. The duration of the signal could be considerably shorter than before pregnancy and still allowed perception of the signal. Eisenberg (1956) also reported that these time thresholds were markedly shorter during menses, and perfectly normal during the interval between menses.

During a temporal integration study of females during menses and post menses, using a Bekesy procedure, and using signal durations of 500 msec down to 20 msec, no significant change in temporal integration occurred (Meyer and Schubert, 1975). It was noted, however, that some subjects apparently had enhanced thresholds at 4 KiloHertz (KHz) for a 500 msec tone to the extent that tracings went above the calibrated part of the Bekesy chart. This did not occur at other frequencies such as 1 KHz and 2 KHz. Further investigation of this phenomena was not investigated and these subjects were excluded from the study.

It is the purpose of this study to investigate the apparent improvement of sensitivity to brief pulsed tones during menses.

Since there is indication that an increase in threshold sensitivity was occurring at 4 KHz (Meyer and Schubert, 1975), this was one of the frequencies used in this study. However, for the purpose of comparison, thresholds at 4 KHz and 1 KHz were scrutinized. Apparently, the auditory mechanism responds differently at 1 KHz and below than it does at 4 KHz. The slope of integration is slightly steeper at frequencies below 1 KHz than at 4 KHz (Hempstock, Bryan, and Tempest, 1964).

In order to investigate this apparent enhancement of sensitivity at 4 KHz during menses, threshold had to be artificially raised in order to have the tracing remain within the calibrated portion of the Bekesy chart. This was accomplished by using signals with durations shorter than 200 msec, for example, 2 msec and 20 msec.

When using pulsed tones, there are three factors which may influence measured thresholds. These are: (1) duration of the signal, (2) repetition rate of the signal, and (3) rise-decay time of the signal. These factors are discussed in the following paragraphs.

Duration of the signal

The physical spectrum of a tone varies with its duration. Any tone which is attenuated in time is no longer a pure tone; multiples of the fundamental frequency are generated and the total energy of the signal is distributed between the fundamental and the generated side bands (Doughty and Garner, 1947). Using a formula proposed by Doughty and Garner (1947), $F_o \pm 1/d$, where F_o is the frequency of oscillation, d is duration in msec, and 1 is equal to 1000 msec, a 20 msec tone has a main band spread of $\pm$50 Hz. Therefore, at 4 KHz the main band of frequencies of a 20 msec tone would occur in a band from 3950 Hz to 4050 Hz ($\pm$50 Hz). The energy outside of this main band is very small compared to the energy in the main band and can be ignored. According to Garner (1947b), the ear will integrate acoustic energy best if all energy is within a relatively narrow band of frequencies.

Repetition rate of the signal

Only when the repetition rate of the signal is greater than five signals per second, does threshold show a significant improvement (Garner, 1947a). Garner also found that duration of the signal has more effect on threshold than repetition rate.

Rise-decay time of the signal

If a tone of 500 msec or 100 msec duration is presented with a fast rise-decay time, the resulting auditory stimulus can best be considered as having clicks at the ends of the stimulus, with some sense of definable pitch between them (Wright, 1958). The subject awareness of a definite pitch is dependent upon total duration of the stimulus (Doughty and Garner, 1947). According to Wright (1958), in normal hearing subjects, the presence of clicks in the auditory stimulus did not change threshold when compared with signals of the same duration having a slow rise-decay time. However, in hearing impaired subjects, the presence of clicks improved the thresholds when compared with signals of the same duration having a slow rise-decay time.

The present study investigated the following questions:

1. Is there a significant difference in threshold measured

during menses and post menses at 1 KHz when using a Bekesy procedure?

2. Is there a significant difference in threshold measured during menses and post menses at 1 KHz when using a Bekesy procedure?

3. Is there a significant difference in threshold measured at seven to nine days post menses and fourteen to sixteen days post menses at 4 KHz using a Bekesy procedure?

4. Is there a significant difference in threshold measured at seven to nine days post menses and fourteen to sixteen days post menses at 1 KHz using a Bekesy procedure?

CHAPTER II

PROCEDURE

Subjects

The subjects used in this study were sixteen females between the ages of nineteen and twenty-eight years with a mean age of twenty-two years and four months. All had normal hearing thresholds of 15 dB (ANSI, 1969) in the ear that data was collected on between the frequencies of 250 Hz to 6000 Hz. Subjects were screened using a Bekesy procedure to familiarize them with the tracing task. All subjects completed a questionnaire inquiring about history of ear problems, irregularity or regularity of menses, and the use or non-use of oral contraceptives. All subjects used in this study reported negative history of ear problems and regularity of menses. Nine subjects reported the use of an oral contraceptive, while seven subjects did not report the use of an oral contraceptive. Subjects were not informed of the purpose of the study.

Equipment

All experimental sessions occurred within a double walled Industrial Acoustics Company booth using a Grason-Stadler (GS audiometer (GS 1701), two interval timers

(GS 1216 A) and an electronic switch (GS 12878 B) to shape the signals.

Signal duration times were 500 msec, 20 msec, and 2 msec. The 500 msec and 20 msec signals had a rise-decay time of 5 msec and the 2 msec signal had a fast rise-decay time (approximately 250 microseconds). The signal durations were set as defined by Wright (1968) as between 10 percent and 90 percent of the maximum amplitude of the signal. Signal attentuation rate was 2.5 dB per second. The off times used were 750 msec for the 500 msec signal and 500 msec for the 2 msec and 20 msec signal. Test signals were reproduced by a Telephonix TDH-49 earphone mounted in a MX-41 AR cushion.

Audiometer calibration was checked with a Bruel and Kjaer sound level meter (Model 159) forty-eight hours prior to collection of data, periodically during data collection, and within forty-eight hours after the completion of data collection. Signal duration and rise-decay time were checked forty-eight hours prior to data collection of data, periodically during data collection, and within forty-eight hours after the completion of data collection with a storage oscilloscope (Tektronix 515A). Output of the signal remained within $\pm$.75 dB. The signal outputs from the electronic switch and two timers remained unchanged throughout the study.

Method

Before hearing screening, subjects read typewritten instructions for the Bekesy tracing procedure (Appendix A). Subjects were then provided with additional verbal instructions if they were uncertain. The subjects were then screened using a sweep Bekesy tracing procedure. No further instructions were given during the data collection process.

Each subject was assigned a number after they had completed the questionnaire. Left ears were tested on even numbered subjects; right ears were tested on odd numbered subjects. Alternate subjects in each ear group began the test at 1 KHz. Presentation of the different signal durations was randomized (Appendix B). The sequence of frequency and signal duration remained constant for each subject throughout the study. Each subject received a minimum of one minute practice at each signal duration. The same earphone was used for all subjects throughout the study.

The Bekesy instruction, hearing screening, and the first test occurred within forty-eight hours of the onset of menses. The second test occurred within seven to nine days after the onset of menses while the third test occurred within fourteen to sixteen days after the onset.

Each combination of frequency and duration was presented for one and a half to two minutes. Threshold was computed by averaging the extremes of ten consecutive crossing of threshold at the most stable portion of the tracing.

CHAPTER III

RESULTS AND DISCUSSION

Analysis of the data was completed by the use of a repeated measures design.

Table 1 shows the mean thresholds for the three signal durations obtained at 1 KHz and 4 KHz at the three test times.

TABLE 1

MEAN THRESHOLDS IN dB
FOR 500 msec, 20 msec AND 2 msec
AT 1 KHz AND 4 KHz AT
THREE TEST TIMES

Frequency	1 KHz			4 KHz		
Test times	1	2	3	1	2	3
Signal Duration						
500 msec	-.10	-.138	.786	-.275	.003	-1.05
20 msec	9.41	8.35	9.18	6.72	7.37	7.86
2 msec	21.58	19.5	21.4	13.84	14.27	14.27

The F-values for the thresholds obtained at 1 KHz and 4 KHz for the three signal durations are shown in

Tables 2, 3, 4, 5, 6, and 7. With 1, 15 degrees of freedom, at the .05 level of significance, an F-value of 4.56 or greater was needed for the linear variation and second variation. With 2, 15 degrees of freedom, at the .05 level of significance, an F-value of 3.68 or greater was needed for the time variation.

TABLE 2

ANALYSIS OF VARIANCE FOR
500 msec AT 1 KHz

Source of Variation	Sums of Squares	df	Mean Squares	F
Time	8.75	2	4.37	.38
Linear	6.28	1	6.28	.55
Second	2.47	1	2.47	.22
Subjects	2341.04	15		
Error	344.22	30	11.47	
Total	2702.76			

[a]F-value required at .05 with 1, 15 df = 4.56

[b]F-value required at .05 with 2, 15 df = 3.68

TABLE 3

ANALYSIS OF VARIANCE FOR 20 msec AT 1 KHz

Source of Variation	Sums of Squares	df	Mean Squares	F
Time	9.97	2	4.49	.63
Linear	.44	1	.44	.06
Second	9.53	1	9.53	1.3
Subjects	905.66	15		
Error	213.66	30	7.12	
Total	1139.26			

[a]F-value required at .05 with 1, 15 df = 4.56

[b]F-value required at .05 with 2, 15 df = 3.68

TABLE 4

ANALYSIS OF VARIANCE FOR 2 msec AT 1 KHz

Source of Variation	Sums of Squares	df	Mean Squares	F
Time	43.67	2	21.83	2.39
Linear	2.54	1	.254	.02
Second	43.42	1	43.42	4.75[a]
Subjects	844.99	15		
Error	274.63	30	9.15	
Total	1209.25			

[a]Significant at the .05 level

[b]F-value required at .05 with 1, 15 df = 4.56

[c]F-value required at .05 with 2, 15 df = 3.68

TABLE 5

ANALYSIS OF VARIANCE FOR 500 msec AT 4 KHz

Source of Variation	Sums of Squares	df	Mean Squares	F
Time	9.56	2	4.78	.195
Linear	4.88	1	4.88	.198
Second	4.68	1	4.68	.190
Subjects	3526.89	15		
Error	736.86	30	24.56	
Total	4282.87			

[a]F-value required at .05 with 1, 15 df = 4.56

[b]F-value required at .05 with 2, 15 df = 3.68

TABLE 6

ANALYSIS OF VARIANCE FOR 20 msec AT 4 KHz

Source of Variation	Sums of Squares	df	Mean Squares	F
Time	10.42	2	5.21	.30
Linear	10.35	1	10.35	.60
Second	.07	1	.07	.004
Subjects	1380.60	15		
Error	1906.51	30	63.55	
Total	3307.95			

[a]F-value required at .05 with 1, 15 df = 4.56

[b]F-value required at .05 with 2, 15 df = 3.68

TABLE 7

ANALYSIS OF VARIANCE FOR 2 msec AT 4 KHz

Source of Variation	Sums of Squares	df	Mean Squares	F
Time	1.95	2	.97	.497
Linear	1.44	1	1.44	.164
Second	.51	1	.51	.058
Subjects	1439.30	15		
Error	263.41	30	8.78	
Total	1706.61			

[a]F-value required at .05 with 1, 15 df = 4.56

[b]F-value required at .05 with 2, 15 df = 3.68

The results indicated that there was no significant difference ($p > .05$) in threshold measured during menses and post menses at 4 KHz or at 1 KHz. The results also indicated that there was no significant differences ($p > .05$) in threshold measured seven to nine days post menses and fourteen to sixteen days post menses.

However, the results did indicate that there was a significant second degree trend present for the 2 msec signal at 1 KHz (see Figure 1).

It is interesting to note that Tobias (1965) found an analogous trend when comparing the cutoff frequencies in females to males for beat perception. The female subjects

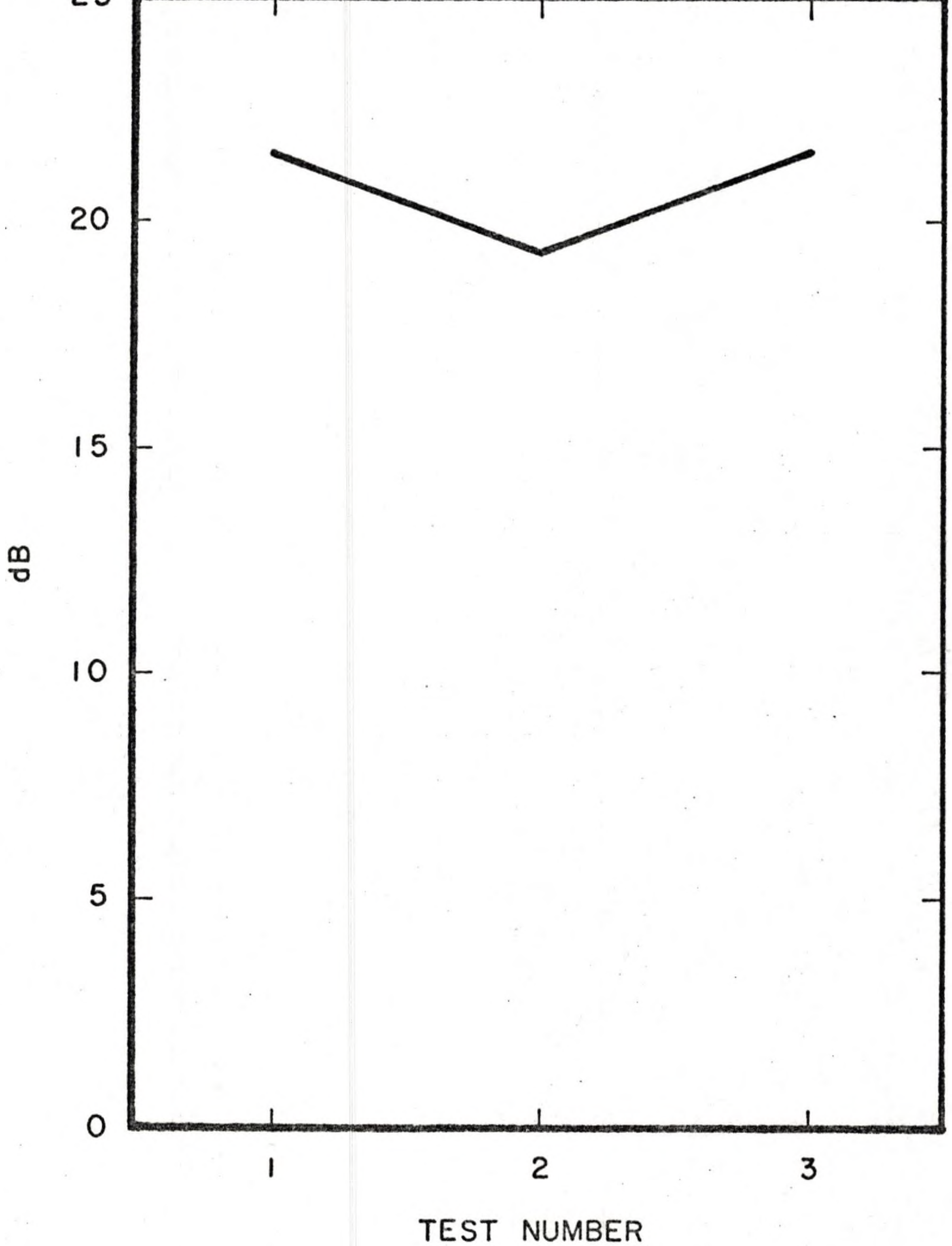

Figure 1. - Second degree trend of 2 msec at 4 KHz.

showed a rise in cutoff frequency at the onset of menses, then a decline to their base levels, and finally a small rise in cutoff frequency about fifteen days later.

The mean thresholds obtained at each frequency are shown in Table 8.

TABLE 8

MEAN THRESHOLDS AT 1 KHz AND 4 KHz

Signal Duration	1 KHz	4 KHz
500 msec	.183 dB	-.44 dB
20 msec	8.980 dB	7.32 dB
2 msec	20.826 dB	14.38 dB

The difference in the thresholds evident between 1 KHz and 4 KHz for 2 msec signal may be explained by the effect of the frequency spectrum described by Garner (1947b).

As a tone becomes shorter and shorter, the effective bandwidth of energy increases and Garner (1947b) hypothesized that only part of this energy contributes to the threshold value. This energy which contributes to threshold occurs within the critical bandwidth. However, the critical bandwidth is smaller for low frequencies and wider for high frequencies. Garner (1947b) hypothesized that at high frequencies such as 4 KHz, the energy spread does not exceed the critical bandwidth until the signal duration approaches 1 msec. Garner further stated that for signal durations less than 4 msec at 1 KHz the effective band of energy exceeds the critical bandwidth. Therefore, a deviation in the expected linear relationship of threshold occurs because more intensity is needed to obtain threshold and the integration slope becomes steeper. Hempstock, Bryan, and Tempest (1964) also found evidence of frequency dependency for thresholds of short signal durations.

When the average thresholds found in this study were compared to those of previous investigators (Plomp and Bowman, 1959; and Hempstock, Bryan, and Tempest, 1964), they were in close agreement at 500 msec for 1 KHz and 4 KHz (see Figure 2). At the 20 msec signal duration, the thresholds obtained in this study were in closer agreement with thresholds obtained by Hempstock, Bryan, and Tempest (1964) than with Plomp and Bowman (1959). The data obtained for the 2 msec signal at 4 KHz and 1 KHz were also in close agreement with those found by Hempstock, Bryan, and Tempest (1964). It was not possible to make any comparison at 1 KHz for the 2 msec signal with Plomp and Bowman (1959), but their results at 4 KHz are divergent from the results of this study at 4 KHz and from the results of Hempstock, Bryan, and Tempest (1964) at 5 KHz.

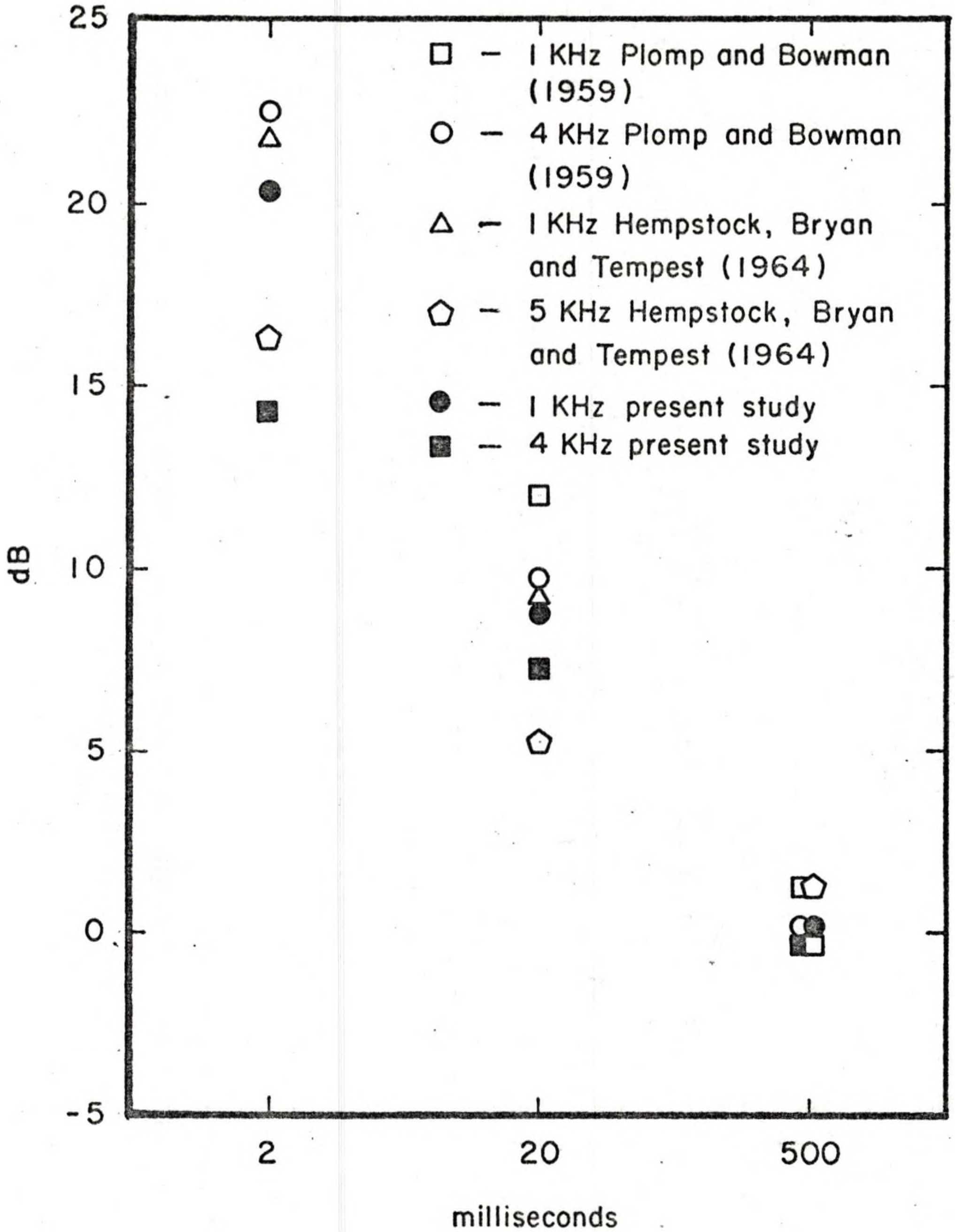

Figure 2. - Thresholds obtained in present study compared to thresholds obtained by previous investigators.

Table 9 shows the mean increase in intensity in deciBels relative to 500 msec at 1 KHz and 4 KHz compared to the results of Plomp and Bowman (1959); Hempstock, Bryan, and Tempest (1964); Olsen and Carhart (1966); and Meyer and Schubert (1975).

TABLE 9

MEAN INCREASE IN INTENSITY IN dB
RELATIVE TO 500 msec AT 1 KHz and 4 KHz

Frequency	1 KHz		4 KHz	
Signal duration	2 msec	20 msec	2 msec	20 msec
Plomp and Bowman (1959)	-	12.5	22.4	9.8
Olsen and Carhart (1966)	-	9.3	-	7.8
Meyer and Schubert (1975)	-	7.3	-	7.8
Present study	20.6	8.8	15.74	7.8
	1 KHz		5 KHz	
Hempstock, Bryan and Tempest (1964)	20.6	8.0	15.2	4.6

Figure 3 illustrates the slope of integration found in this study compared to the theory of temporal summation (Zwislocki, 1960) and the results of Plomp and Bowman (1959);

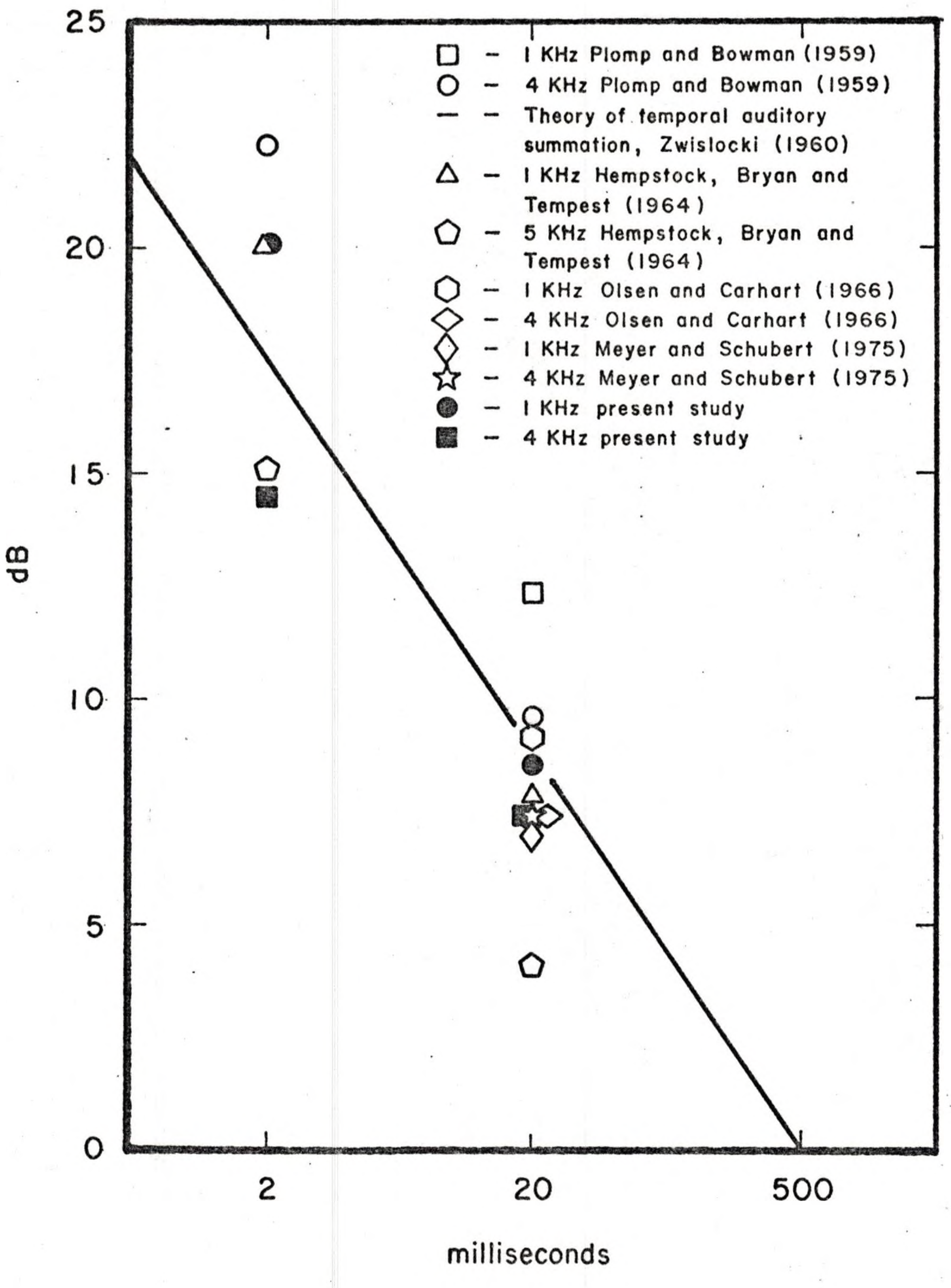

Figure 3. - Slope of integration relative to 500 msec obtained in this study compared to the slope of integration obtained by previous investigators.

Hempstock, Bryan, and Tempest (1964); Olsen and Carhart (1966); and Meyer and Schubert (1975).

The slope of integration found in this study is in close agreement with the theory of temporal summation proposed by Zwislocki (1960) for a 1 KHz signal down to the 2 msec signal duration. It was Zwislocki's (1960) contention that frequency dependency for short durations did not exist. However, the slope of integration obtained in this study at 4 KHz for the 2 msec signal is concurrent with the hypothesis proposed by Garner (1947b) and deviates from the theory of temporal summation (Zwislocki, 1960).

In this study, the finding of frequency dependency for the 2 msec signal at 4 KHz is also in agreement with Hempstock, Bryan, and Tempest (1946). The slope of integration found in this study is also similar to that found by Plomp and Bowman (1959); Hempstock, Bryan and Tempest (1964); Olsen and Carhart (1966); and Meyer and Schubert (1975).

A comparison was made between the thresholds obtained by nine subjects who were using an oral contraceptive and seven subjects who were not. With 15 degrees of freedom, at the .05 level of significance, a t-value of 2.021 was needed between the thresholds at any duration (see Table 10). A significant difference (p .05) between the groups was found at 4 KHz for the 2 msec signal duration. The

TABLE 10

COMPARISON OF
THRESHOLDS AT 1 KHz AND 4 KHz
FOR 500 msec, 20 msec, AND 2 msec
FOR ORAL CONTRACEPTIVE GROUP AND
NO ORAL CONTRACEPTIVE GROUP

	1 KHz		
Group	500 msec	20 msec	2 msec
Oral Contraceptive	-1.09	7.9	20.08
No Oral Contraceptive	1.82	10.24	21.73
t-value	1.33	1.60	1.16

	4 KHz		
Group	500 msec	20 msec	2 msec
Oral Contraceptive	-2.35	6.44	12.57
No Oral Contraceptive	2.0	8.47	16.11
t-value	1.59	1.07	2.09[a]

[a]Significant beyond the .05 level (t=2.021)

group of subjects who were using oral contraceptives obtained threshold at a lower intensity than did the group not using oral contraceptives at 4 KHz for the 2 msec signal duration.

As previously stated, Eisenberg (1956) reported reduced time-thresholds occurred during early pregnancy. The duration of the signal was considerably shorter preceding pregnancy than during pregnancy, but still allowed perception of the signal. Time-threshold, as used by Eisenberg (1956), is the duration of the signal at a fixed intensity, that is required in order to become a threshold stimulus to a subject. For example, if a 12 dB signal requires a duration of 20 msec to be perceived post menses, but only 10 msec duration to be perceived during menses, this would represent a reduced time-threshold. However, the slope of integration down to 2 msec for both groups is in close agreement (see Table 11). In this study, subjects using oral contraceptives exhibited reduced time-thresholds as compared to those subjects not using oral contraceptives.

TABLE 11

COMPARISON OF THE MEAN INCREASE IN INTENSITY IN dB RELATIVE TO 500 msec AT 1 KHz AND 4 KHz FOR ORAL CONTRACEPTIVE GROUP AND NO ORAL CONTRACEPTIVE GROUP

Frequency	1 KHz		4 KHz	
Signal duration	2 msec	20 msec	2 msec	20 msec
Group				
Oral Contraceptive	21.17	8.99	14.92	8.79
No Oral Contraceptive	19.91	8.42	14.11	6.47

CHAPTER IV

SUMMARY AND CONCLUSIONS

The purpose of this study was to determine if threshold change occurred during menses and two post menses time periods. Sixteen female subjects, using the Bekesy tracing method, determined thresholds for 1 KHz and 4 KHz for signal durations of 2 msec, 20 msec, and 500 msec.

The results indicated that there was no significant difference ($p > .05$) for the thresholds of 1 KHz and 4 KHz at any duration over the three test times. However, there was a significant second degree trend present at 1 KHz for the 20 msec signal.

A comparison was made between the thresholds obtained by nine subjects who were using an oral contraceptive and seven subjects who were not. A significant difference ($p < .05$) between the groups was found at 4 KHz for the 2 msec signal duration in that the group using oral contraceptives obtained threshold at a lower intensity than did the group not using oral contraceptives.

Comparison of the thresholds and the slope of integration obtained in this study was in agreement with previous investigators (Plomp and Bowman, 1959; Hempstock, Bryan and Tempest, 1964; Olsen and Carhart, 1966; and Meyer and Schubert, 1975) and the theoretical slope of Zwislocki (1960). However, for the 2 msec signal at 4 KHz, the slope of integration obtained in this study deviated from the theory of temporal summation (Zwislocki, 1960) in that the slope of integration was less steep. A difference in the slope of integration between frequencies was previously noted by Garner (1947b); and Hempstock, Bryan and Tempest (1964). This is in contradiction to Zwislocki's (1960) contention that the slope of integration does not show frequency dependency, but in agreement with Garner's (1947b) frequency dependency hypothesis.

A speculation can be made about the significant second degree trend found at 1 KHz for the 2 msec signal which is analogous to the findings of Tobias (1973). Tobias noted a rise in the cutoff frequency for beat perception at the onset of menses, then a decline to their base levels seven days later, and finally a small rise in cutoff frequency about fifteen days later. All results of Tobias (1973) were necessarily obtained with signals below 1 KHz between the frequencies of 300 Hz and 800 Hz. The present study noted an increase in threshold sensitivity at the onset of menses, a decrease in threshold sensitivity seven to nine days post menses, and an increase in threshold sensitivity fourteen to sixteen days post menses at 1 KHz for a 2 msec signal duration. Garner (1947b) reported that the slope of integration at 250 Hz at durations of less than 20 msec tends to decrease at very short durations, because the band of energy exceeds the critical bandwidth. Previous investigators (Hempstock, Bryan, and Tempest, 1964; and Olsen and Carhart, 1966) have reported that an increase in the slope of integration occurs at 250 Hz for signal durations down to approximately 20 msec.

Also, results of the present study indicate a reduced threshold at 4 KHz with subjects using oral contraceptives for a 2 msec signal. This is analogous to data obtained on a pregnant subject (Eisenberg, 1956).

In view of the reported change in the slope of integration at 250 Hz (Garner, 1947b; Hempstock, Bryand, and Tempest, 1964; and Olsen and Carhart, 1966) and the difference in the perception of beats in females during menses and post menses (Tobias, 1973), and reduced time-thresholds during pregnancy and for subjects using oral contraceptives, it is suggested that the slope of integration for females be investigated using low frequencies with signal durations less than 10 msec.

APPENDIX A

INSTRUCTIONS GIVEN TO SUBJECTS PRIOR TO ADMINISTRATION OF TEST

You are going to hear a pulsing tone that will occur about once a second. Press the button as soon as you hear the pulsating tones and hold the button down until the series of pulsating tones disappears. As soon as the tones have disappeared, release the button. Please keep your eyes closed.

APPENDIX B

RANDOMIZATION OF FREQUENCY AND SIGNAL DURATION FOR EACH SUBJECT

Subject Number	Ear Tested	Frequency Order	Signal Duration Order
1	Right	1 KHz; 4 KHz	500 msec, 20 msec, 2 msec
2	Left	1 KHz; 4 KHz	2 msec, 20 msec, 500 msec
3	Right	4 KHz; 1 KHz	500 msec, 2 msec, 20 msec
4	Left	4 KHz; 1 KHz	20 msec, 2 msec, 500 msec
5	Right	1 KHz; 4 KHz	500 msec, 20 msec, 2 msec
6	Left	1 KHz; 4 KHz	2 msec, 500 msec, 20 msec
7	Right	4 KHz; 1 KHz	20 msec, 500 msec, 2 msec
8	Left	4 KHz; 1 KHz	500 msec, 20 msec, 2 msec
9	Right	1 KHz; 4 KHz	2 msec, 500 msec, 20 msec
10	Left	1 KHz; 4 KHz	20 msec, 500 msec, 2 msec
11	Right	4 KHz; 1 KHz	2 msec, 20 msec, 500 msec
12	Left	4 KHz; 1 KHz	500 msec, 2 msec, 20 msec
13	Right	1 KHz; 4 KHz	20 msec, 2 msec, 500 msec
14	Left	1 KHz; 4 KHz	2 msec, 20 msec, 500 msec
15	Right	4 KHz; 1 KHz	500 msec, 20 msec, 2 msec
16	Left	4 KHz; 1 KHz	2 msec, 20 msec, 500 msec

GLOSSARY

Attenuation rate: deciBels per second change in intensity.

deciBel (dB): a logarithmic ratio unit indicating by what proportion one intensity level differs from another; the deciBel is equal to approximately one just noticeable difference of loudness under certain conditions. Capitalization is in honor of Alexander Graham Bell.

Hertz (Hz): a unit of vibration frequency adopted internationally to replace the term cycles per second after Heinrich Rudolf Hertz, German physicist.

KiloHertz (KHz): equal to 1000 cycles per second or Hertz.

Off-time: the time when the signal is not presented.

Pitch: the psychological correlate of frequency.

Rise-decay time: the time required for a signal to reach its desired output and return from this level to termination.

Slope of Integration: the graphic representation of the dB per decade decrease in threshold of signals with duration times below 200 msec.

Threshold: the intensity level required to make any frequency barely audible to the ear.

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